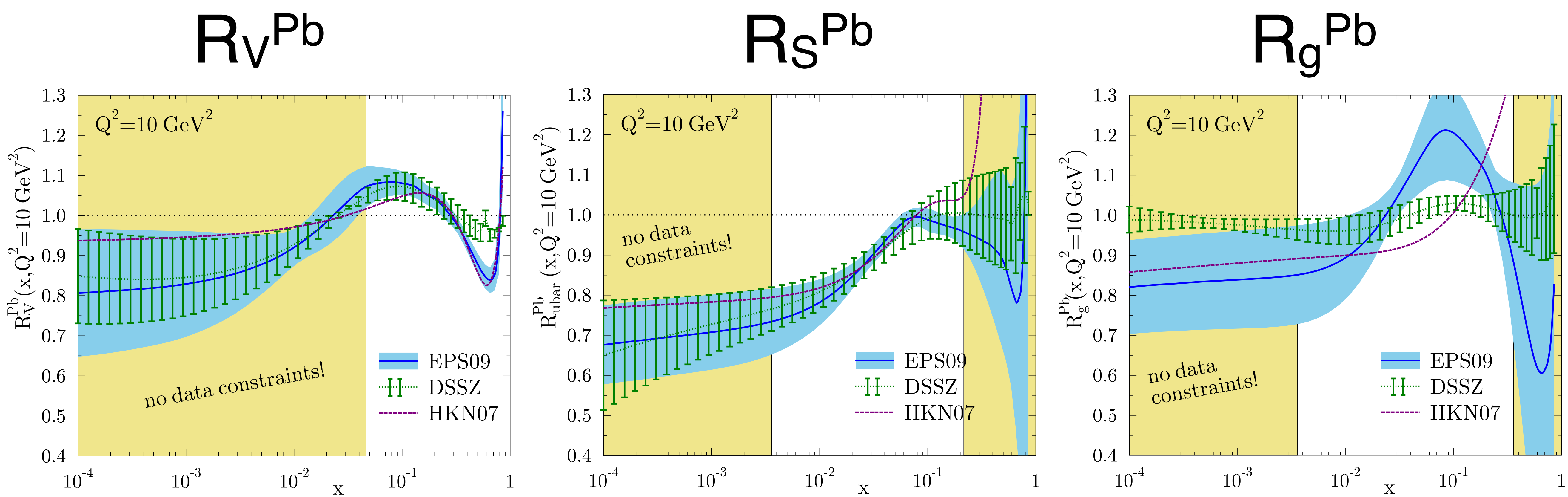
Update on Structure functions in e+A collisions at an EIC

Matthew A. C. Lamont
BNL

What do we know about the structure of nuclei?

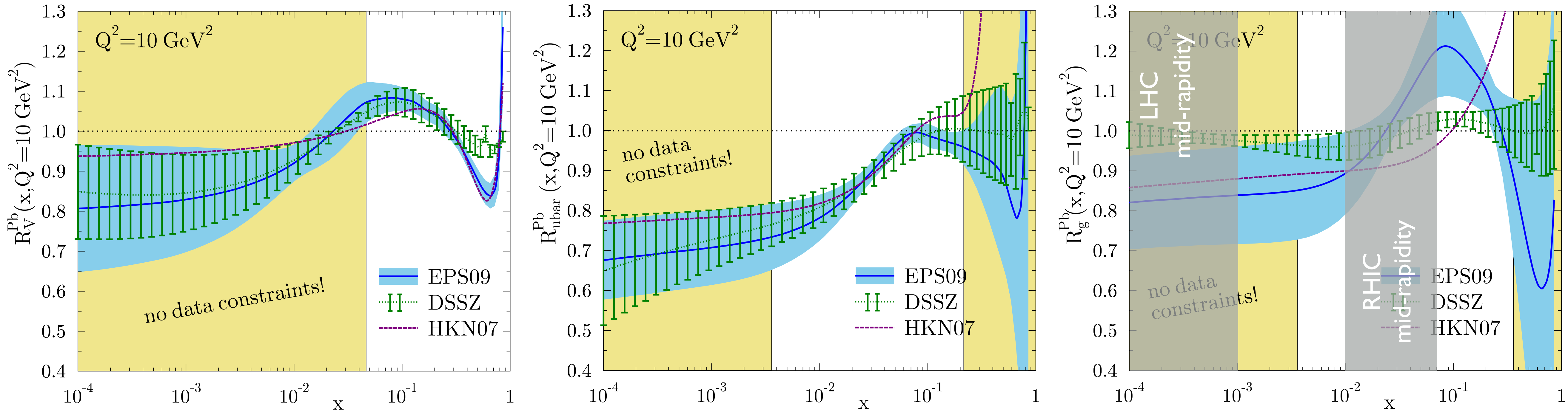


H. Paukkunen

The distribution of valence and sea quarks are relatively well known in nuclei - theories agree well

What do we know about the structure of nuclei?

R_V^{Pb} R_S^{Pb} R_g^{Pb}



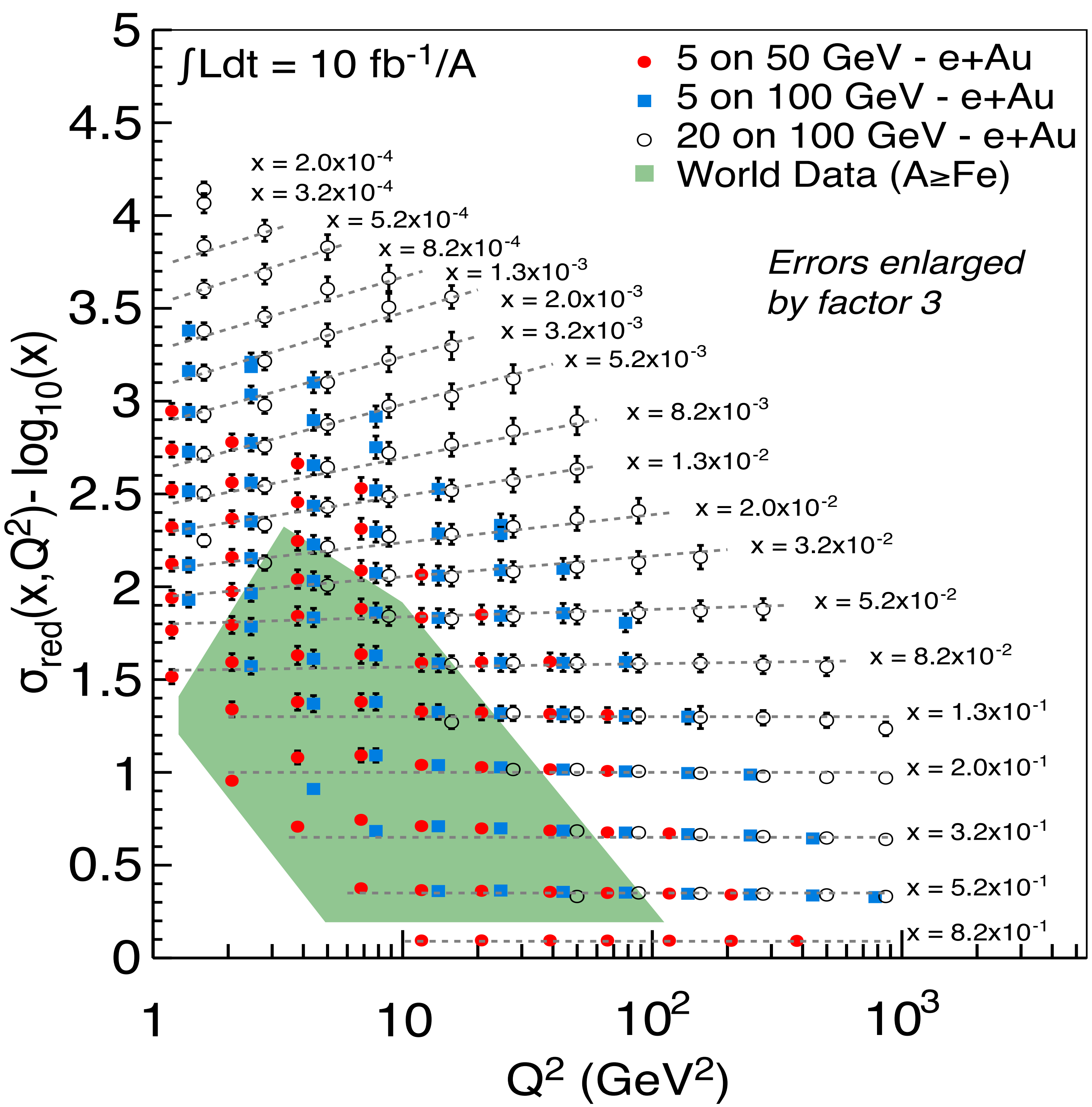
H. Paukkunen

The distribution of valence and sea quarks are relatively well known in nuclei - theories agree well

Large discrepancies exist in the gluon distributions from models for mid-rapidity LHC and forward RHIC rapidities, even for Q^2 = 10 GeV^2

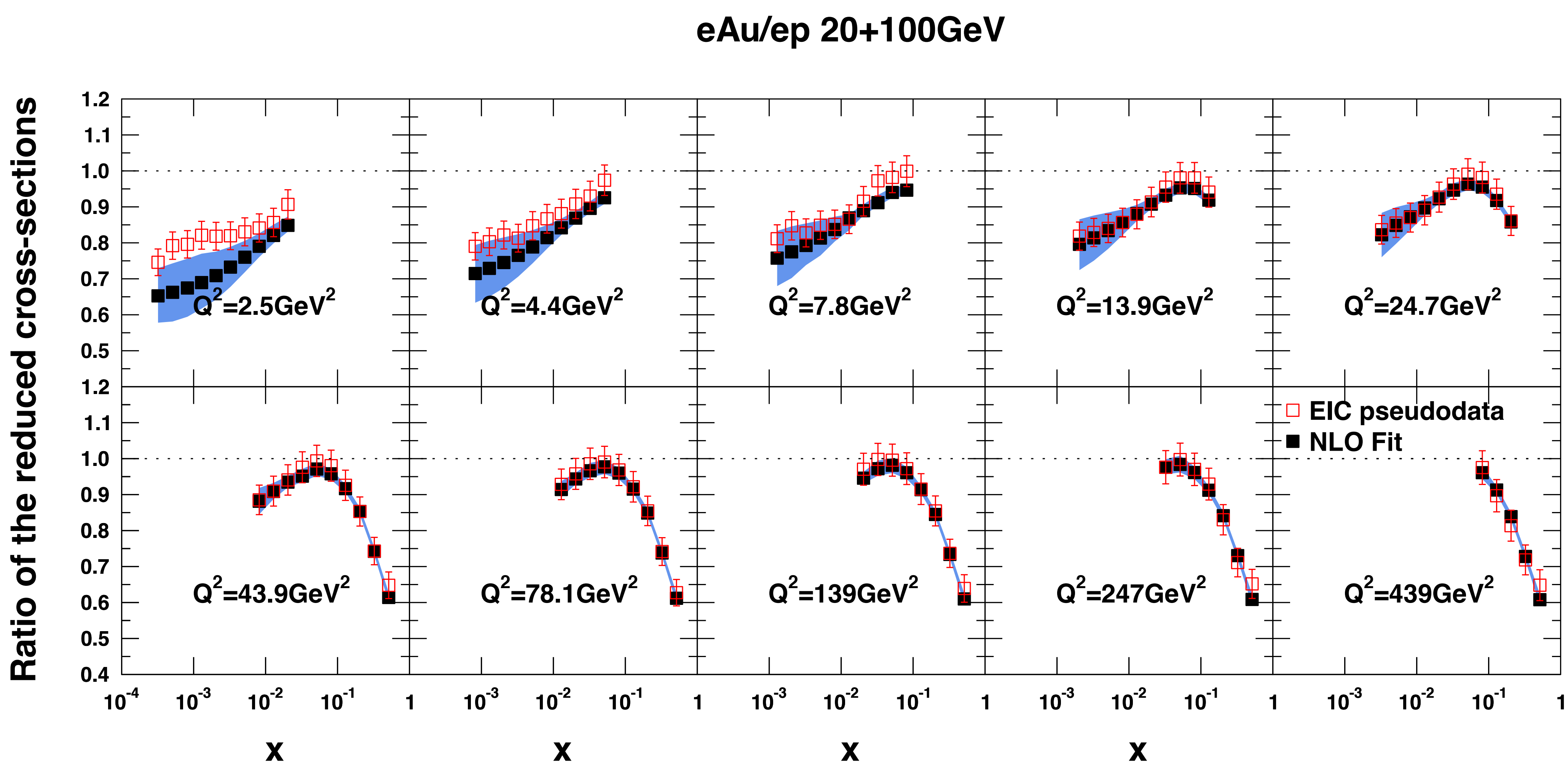
macl@bnl.gov

Reduced cross-section



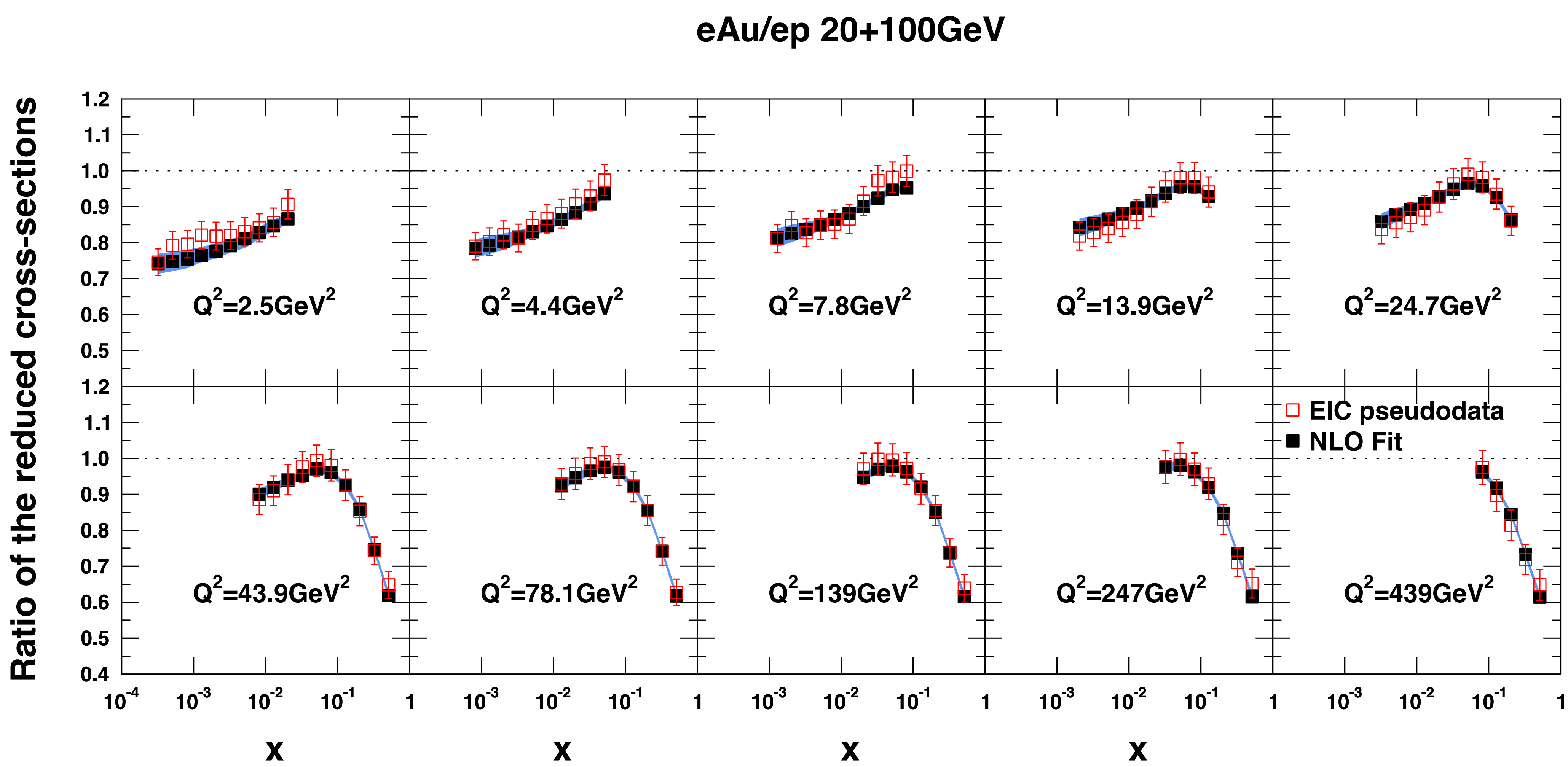
- Large coverage in (x,Q^2)
- Extends the current data
  - ➡ Both reach and in statistics
- Low-statistics should be able to help constrain the EPS09 uncertainties

Old Fits from Hannu



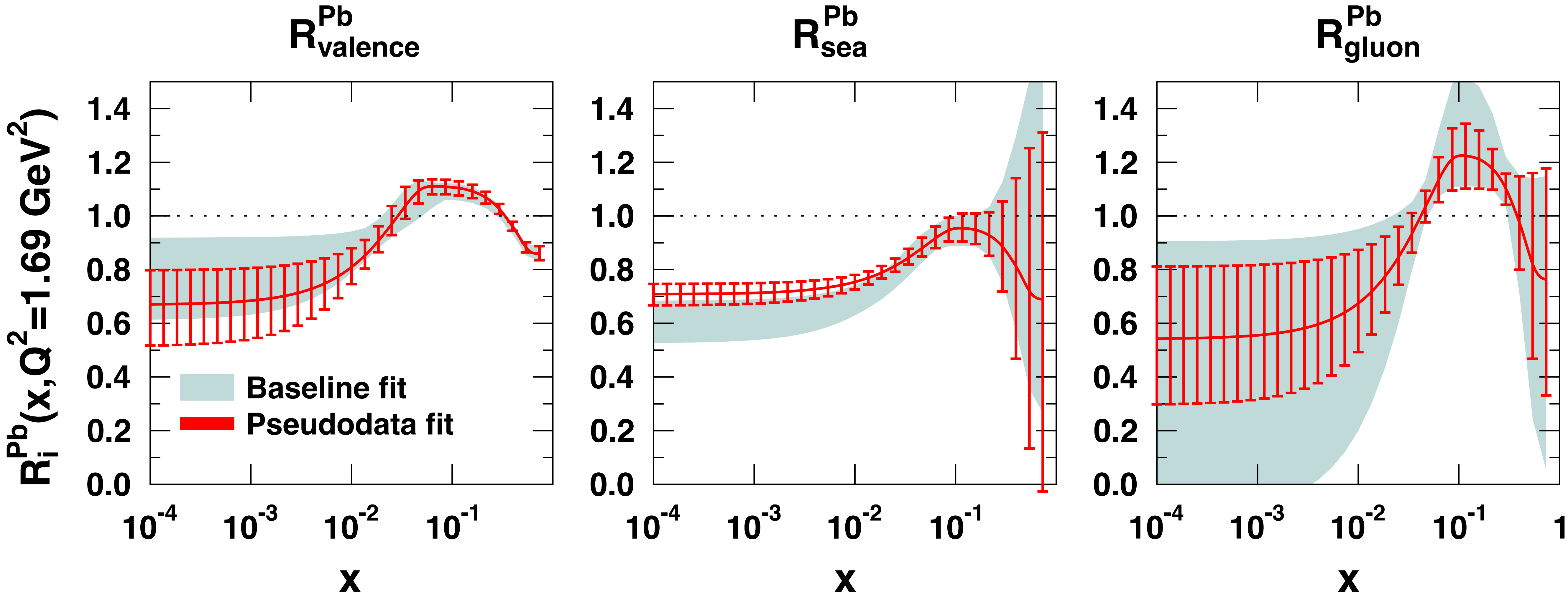
- Psuedo-data is above the current EPS09 fit
    - ➡ Comes from the simulation process where Pythia is not an NLO MC generator

Old Fits from Hannu



- Psuedo-data is above the current EPS09 fit
  - ➡ Comes from the simulation process where Pythia is not an NLO MC generator

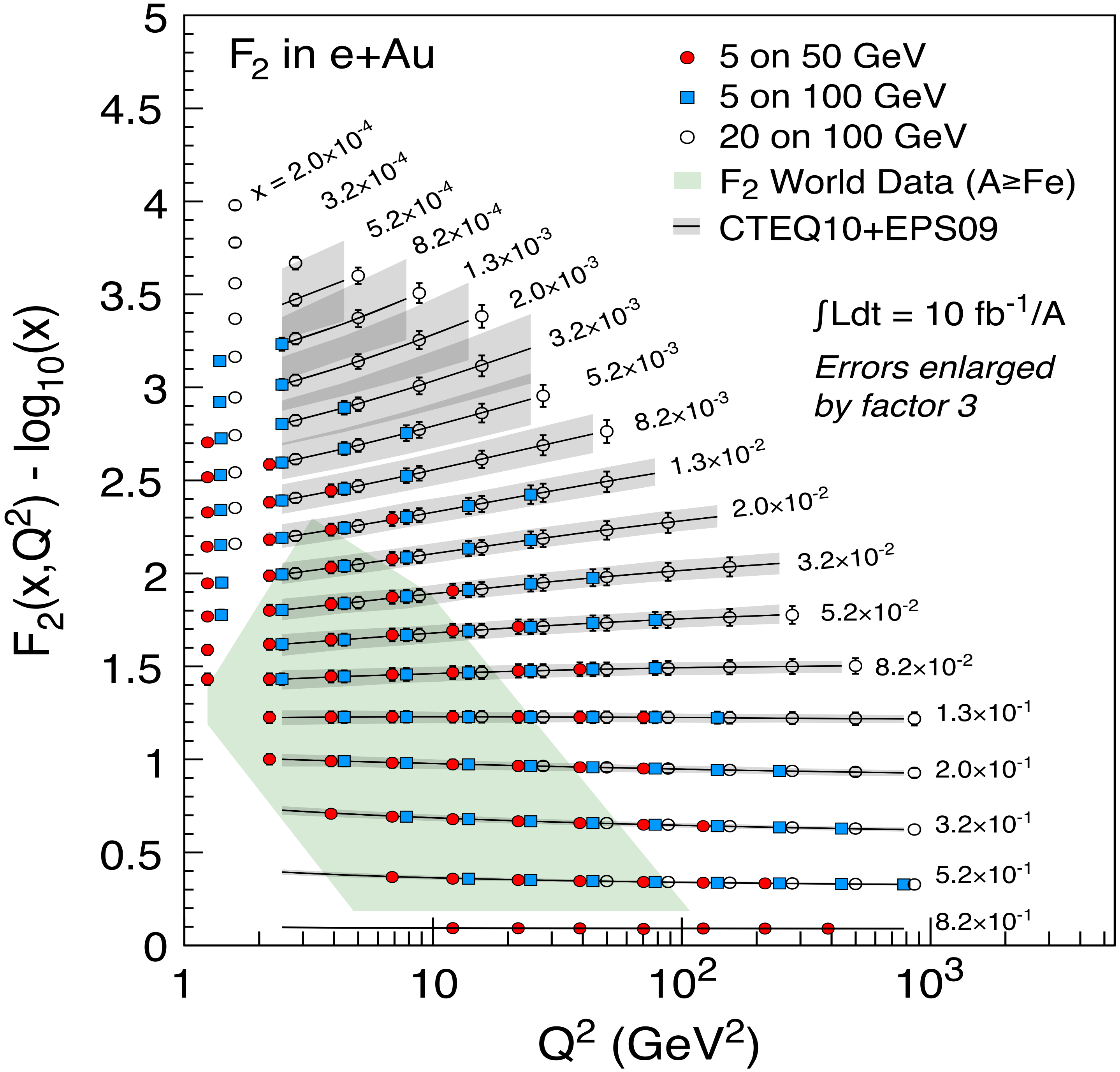
Old Fits from Hannu



- Psuedo-data is above the current EPS09 fit
  - ➡ Comes from the simulation process where Pythia is not an NLO MC generator

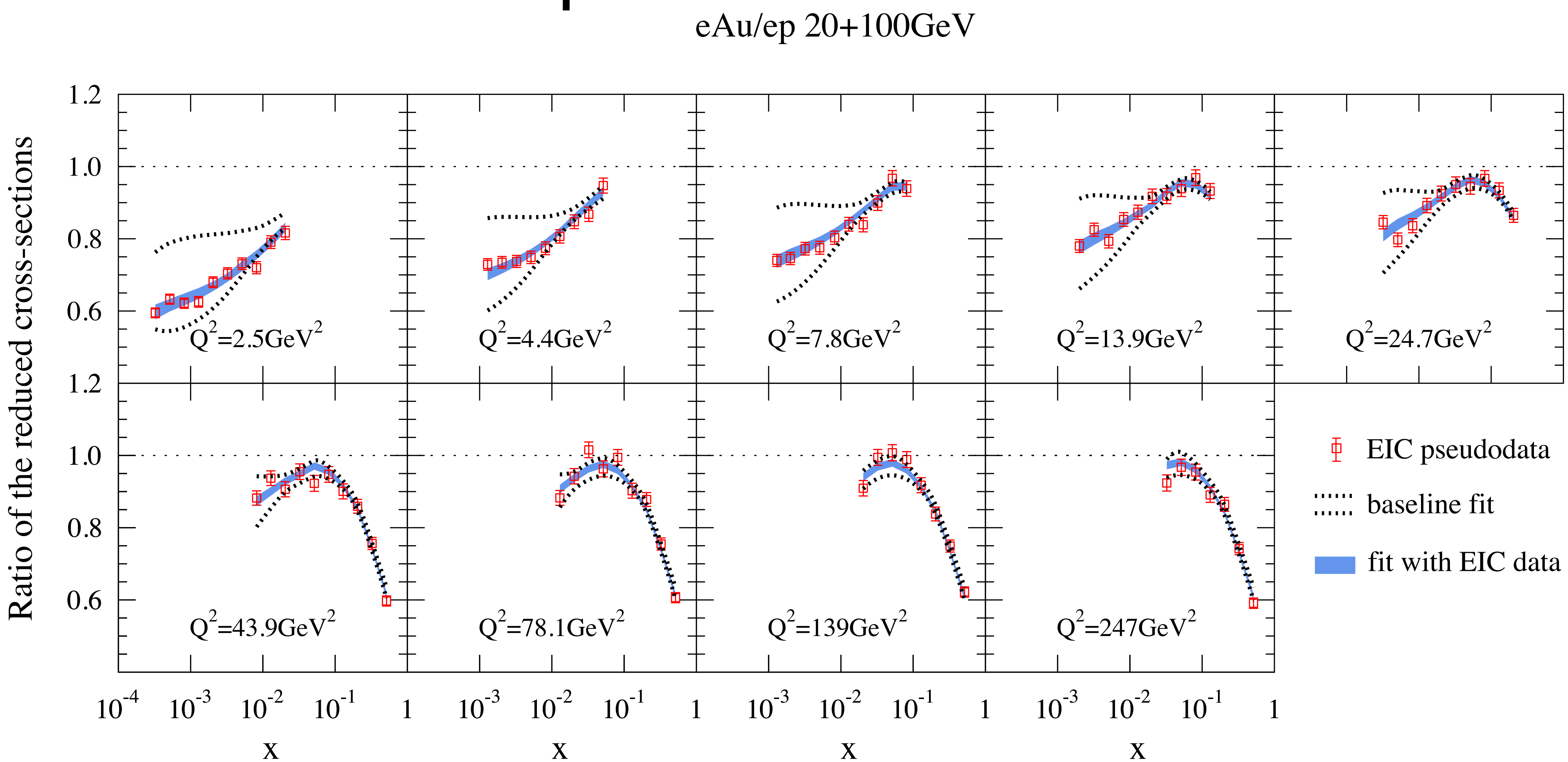
Inclusive nDIS - F_2^A Structure Function

$$\sigma_r = \left(\frac{d^2\sigma}{dx dQ^2}\right) \frac{xQ^4}{2\pi\alpha^2[1+(1-y)^2]} = F_2(x,Q^2) - \frac{y^2}{1+(1-y)^2} F_L(x,Q^2)$$



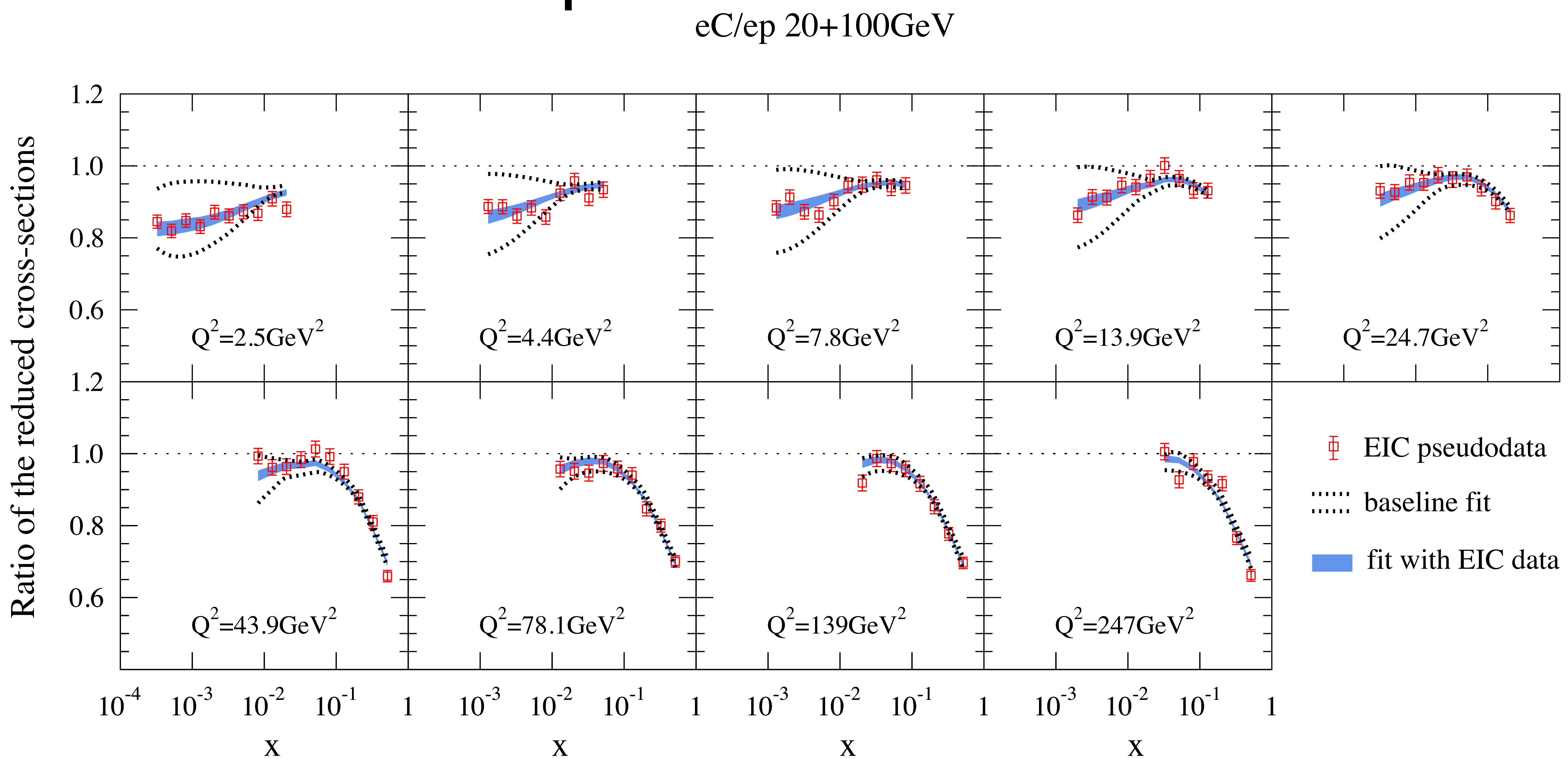
- Use HERMES method to calculate F_2 from σ_r
- The pseudo-data is scaled to the EPS09 calculation
  - ➡ Errors on pseudo-data and EPS09 are scaled for visibility
- At higher x, uncertainties on EPS09 and pseudo-data are negligible
- At smaller x, pseudo-data uncertainties are much smaller than EPS09

Effect of EIC psuedo-data on EPS09



- Ratio of reduced cross-sections, e+Au/e+p
- Large reduction in the cross-sections at low-Q^2
  - ➡ low-x and low-Q^2 is dominated by gluons and sea-quarks
- High-Q^2 is well constrained with existing data

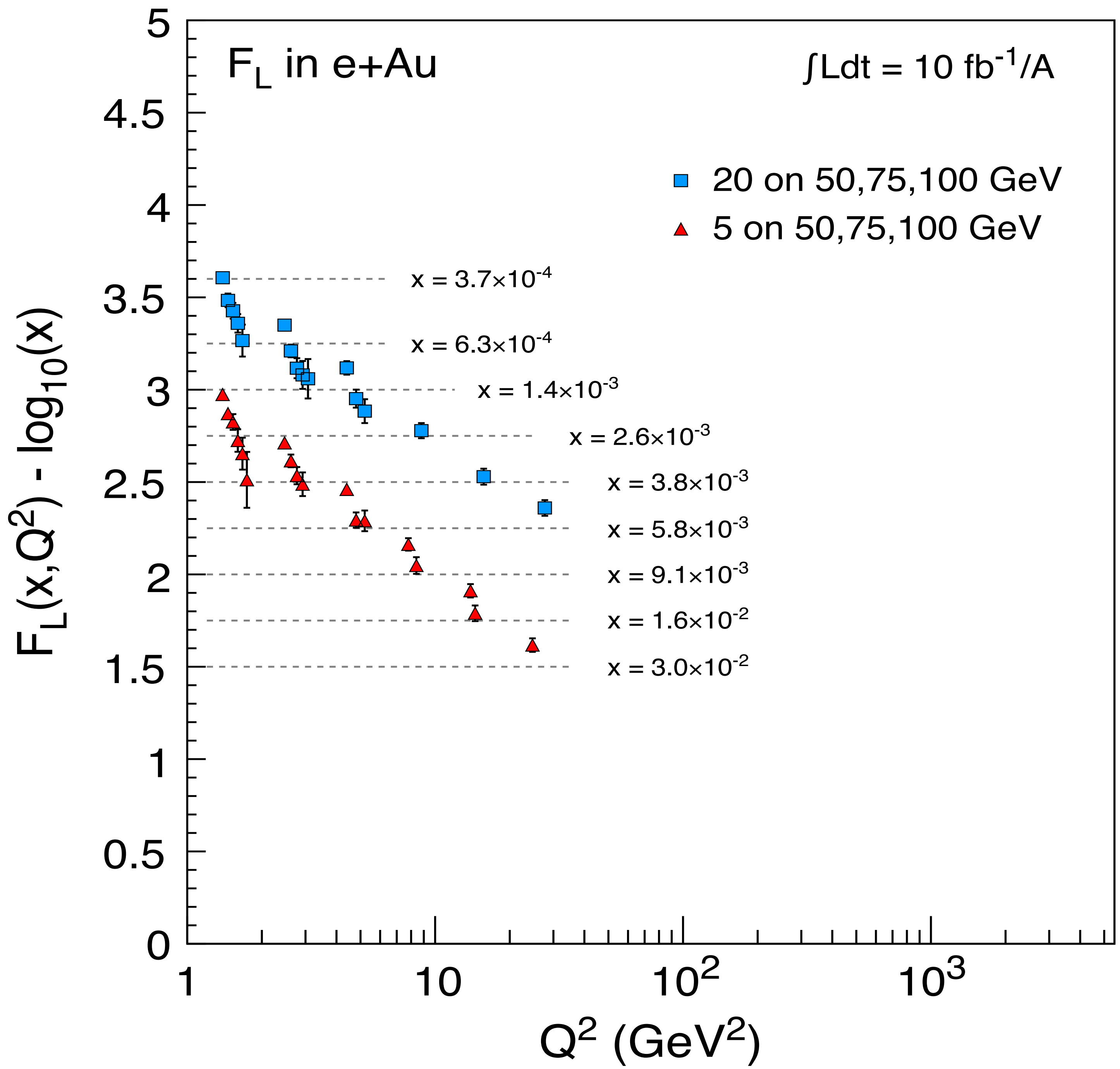
Effect of EIC psuedo-data on EPS09



- Ratio of reduced cross-sections, e+Au/e+p
- Large reduction in the cross-sections at low-Q^2
    - ➡ low-x and low-Q^2 is dominated by gluons and sea-quarks
- High-Q^2 is well constrained with existing data
- The A-dependence of eRHIC allows us to constrain smaller nuclei such as Carbon, which has uncertainties almost as large as Au!

Inclusive nDIS - F_L^A Structure Function

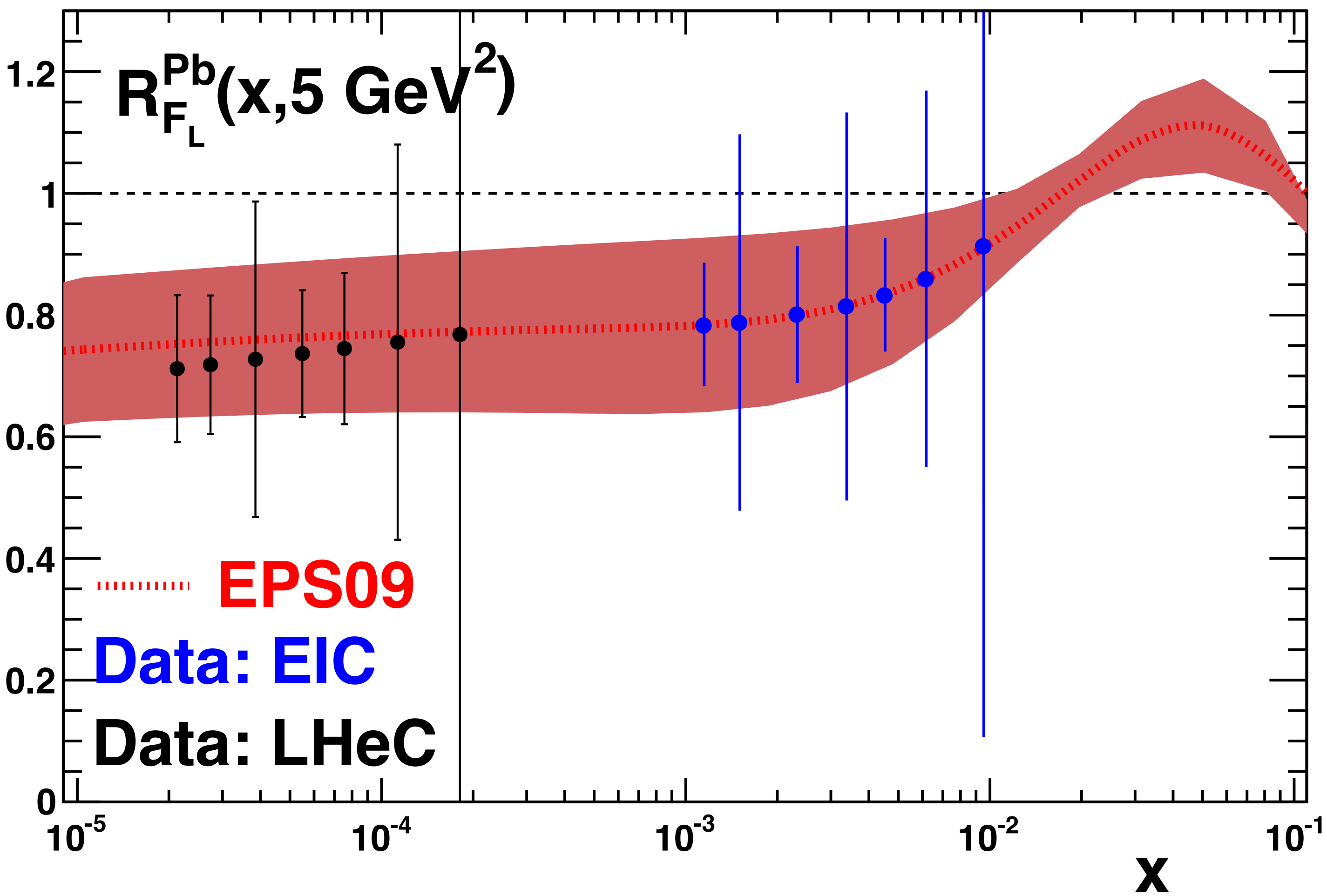
$$\sigma_r = \left(\frac{d^2\sigma}{dxdQ^2}\right)\frac{xQ^4}{2\pi\alpha^2[1+(1-y)^2]} = F_2(x,Q^2) - \frac{y^2}{1+(1-y)^2}F_L(x,Q^2)$$



- The measurement of F_L however is a different beast
- Require data from 3 different energies in each x,Q^2 bin
  - ➡ Use Rosenbluth Separation technique to extract F_L
- Much larger uncertainties and much smaller acceptance than the F_2 measurement

Inclusive nDIS - F_L^A Structure Function

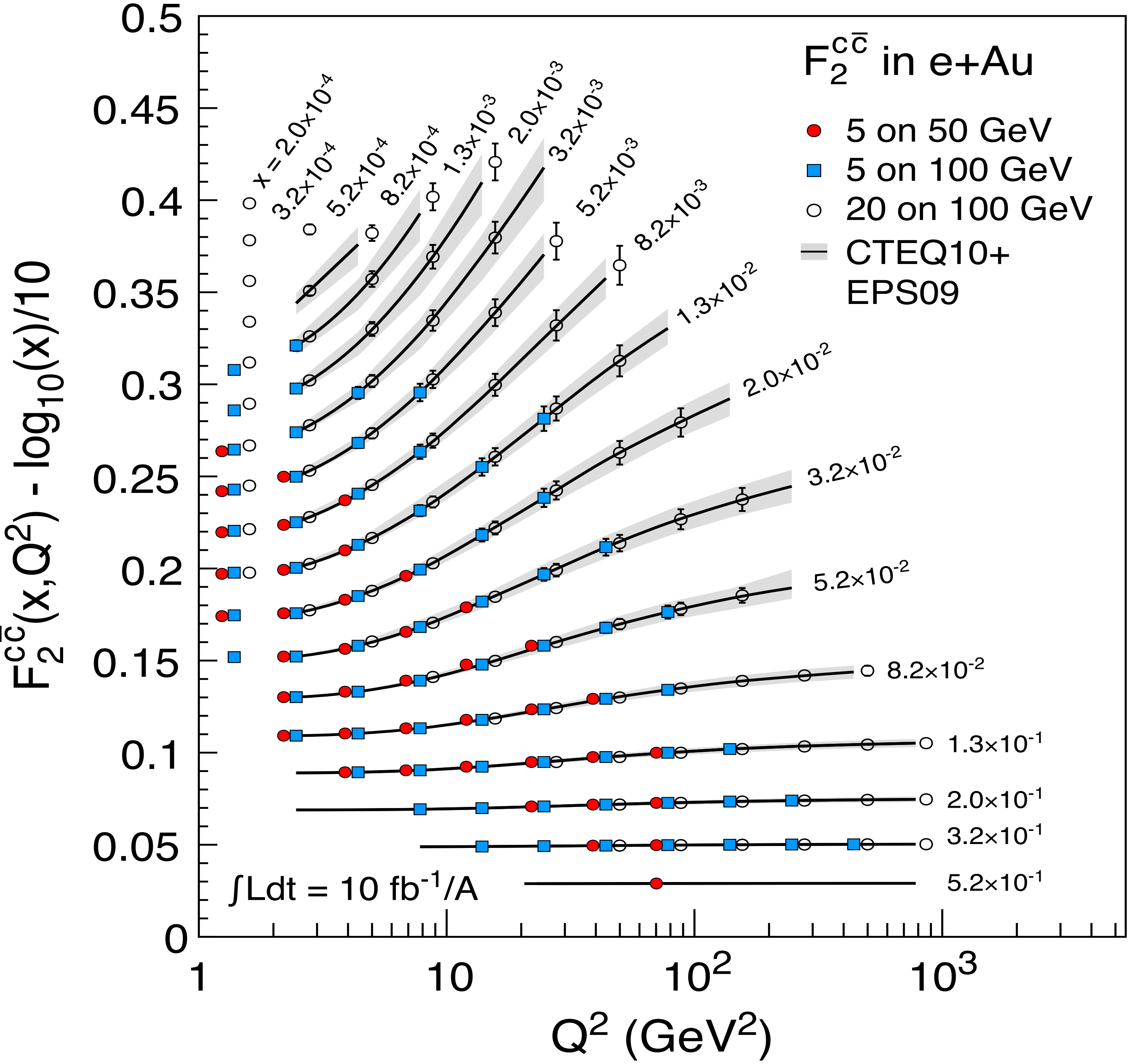
$$\sigma_r = \left(\frac{d^2\sigma}{dxdQ^2}\right)\frac{xQ^4}{2\pi\alpha^2[1+(1-y)^2]} = F_2(x,Q^2) - \frac{y^2}{1+(1-y)^2}F_L(x,Q^2)$$

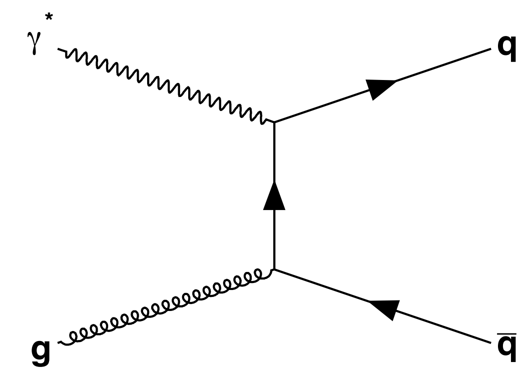


Plot taken from LHeC CDR, courtesy of N. Armesto

- The measurement of F_L however is a different beast
- Require data from 3 different energies in each x,Q^2 bin
  - ➡ Use Rosenbluth Separation technique to extract F_L
- Much larger uncertainties and much smaller acceptance than the F_2 measurement
- Good complementarity with F_L measurement at LHeC
  - ➡ Both measurements are limited by their uncertainties and σ_r is the best way to constrain the nuclear PDFs

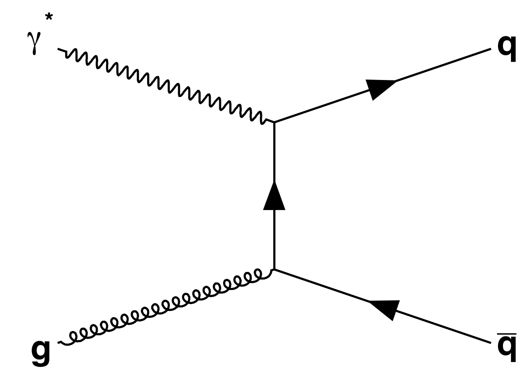
Inclusive nDIS - $F_2^{c,A}$ Structure Function

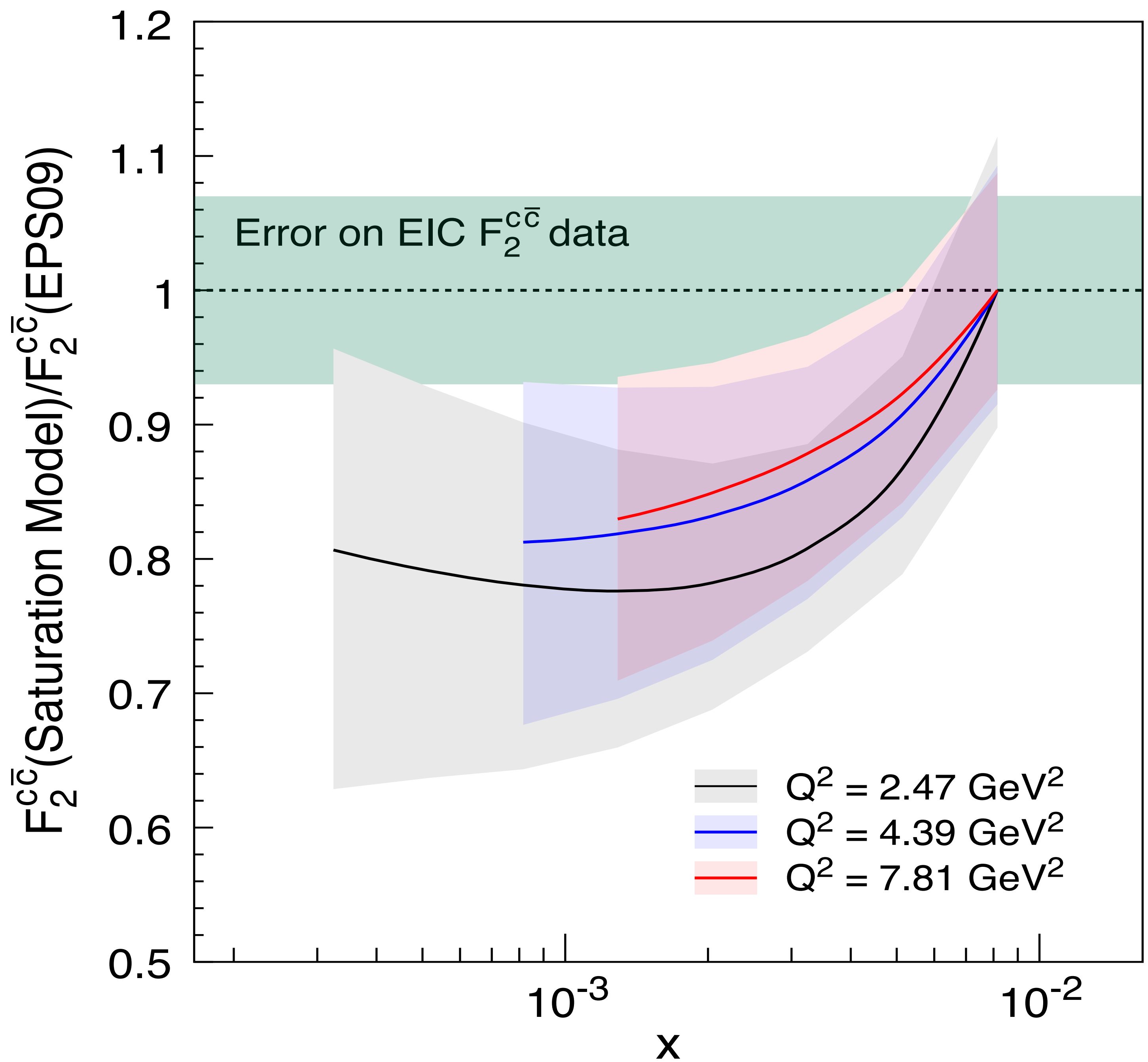




- F_2^c only driven by photon-gluon fusion (PGF)
- As F_L is a difficult measurement, F_2^c may be the way forward
  - ➡ Larger uncertainties than F_2 but smaller than F_L
  - ➡ Statistics are not an issue
- At low x, uncertainties are smaller than EPS09
  - ➡ Will provide some constraints. How much needs to be evaluated

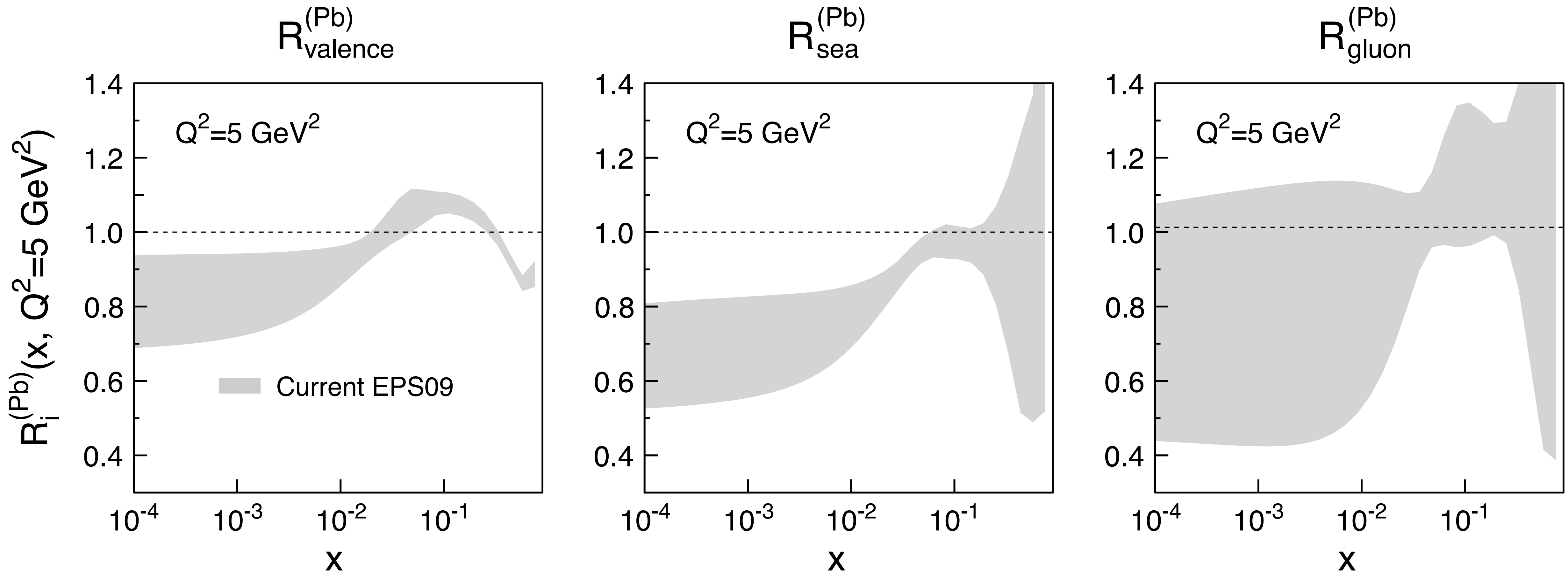
Inclusive nDIS - $F_2^{c,A}$ Structure Function





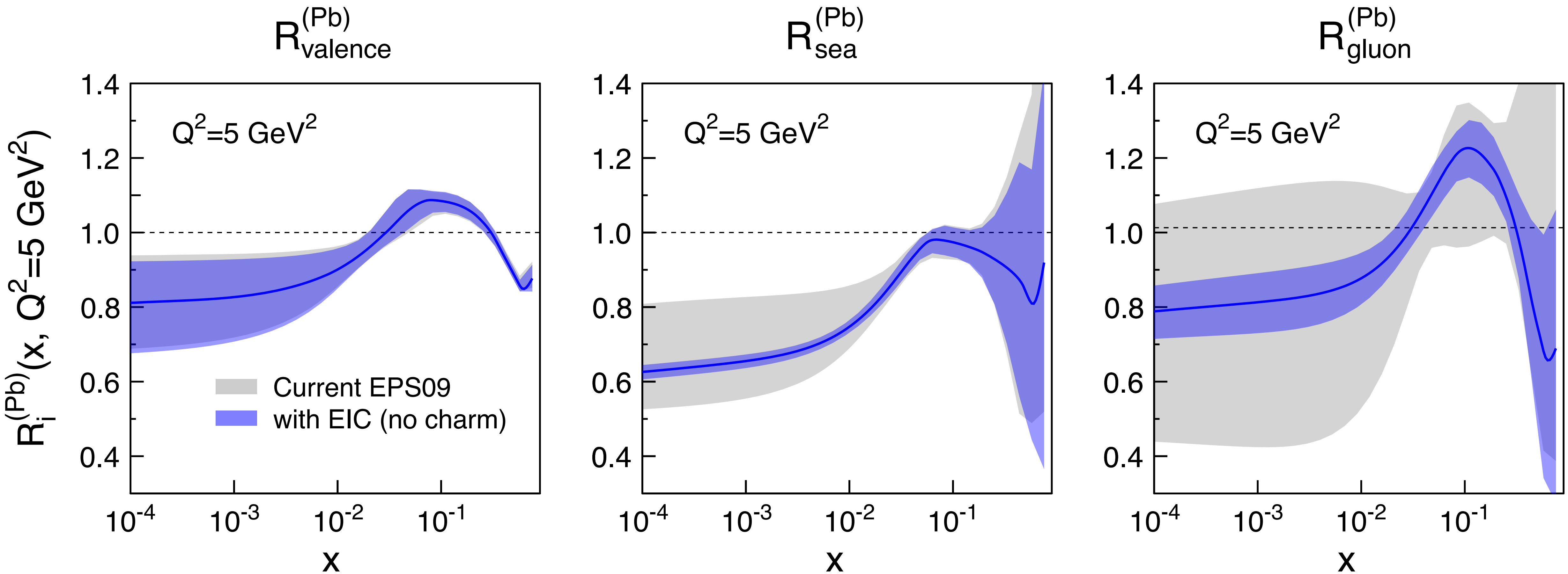
- $F_2^{\ c}$ only driven by photon-gluon fusion (PGF)
- As F_L is a difficult measurement, $F_2^{\ c}$ may be the way forward
  - ➡ Larger uncertainties than F_2 but smaller than F_L
  - ➡ Statistics are not an issue
- At low x, uncertainties are smaller than EPS09
  - ➡ Will provide some constraints. How much needs to be evaluated
- Can provide access to differences between models
  - ➡ Ratio of rcBK to EPS09 shows the possible discriminatory power of this measurement

Effect of EIC psuedo-data on EPS09 fits



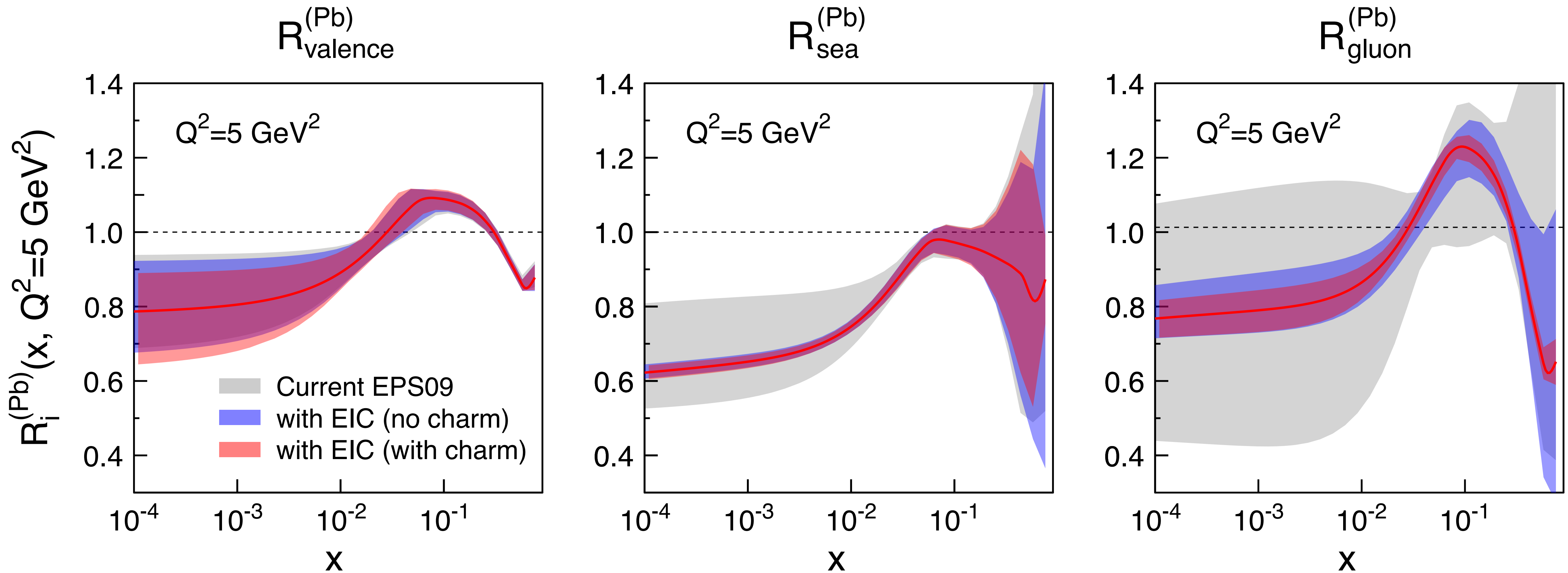
- Ratio of reduced cross-sections, e+Au/e+p
- Without EIC pseudo-data, large uncertainties, especially for sea quarks and gluons

Effect of EIC psuedo-data on EPS09 fits



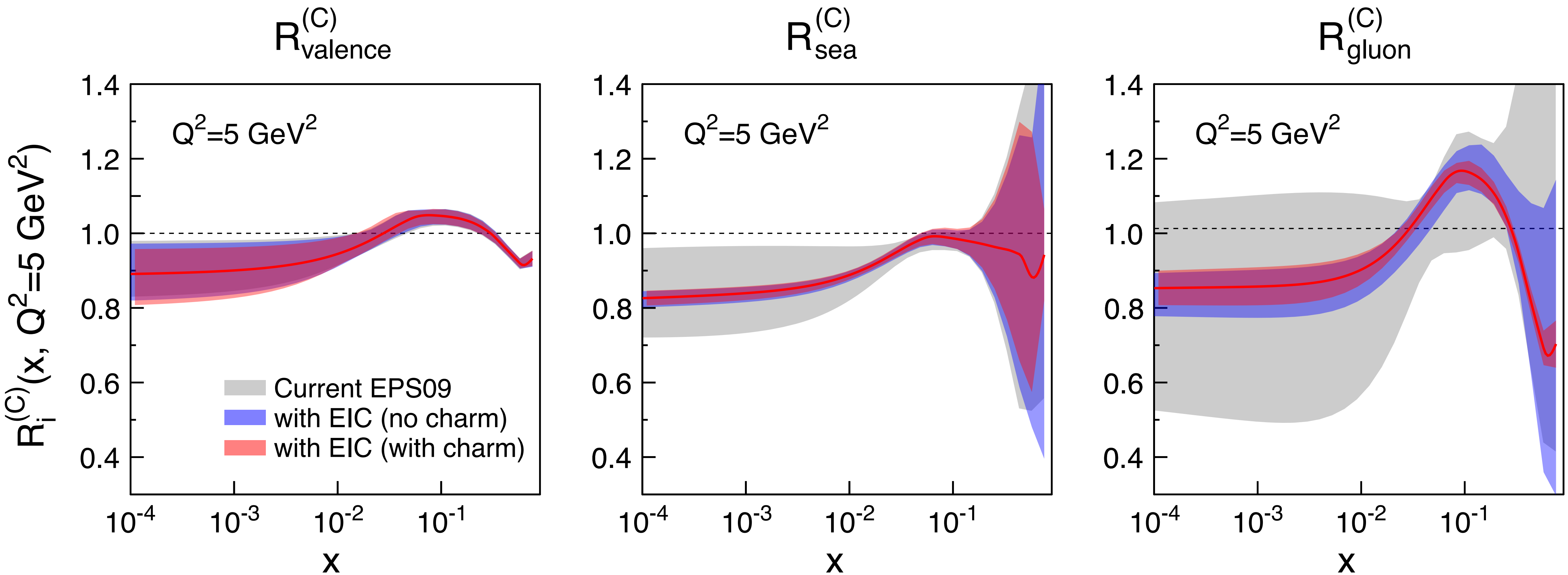
- Ratio of reduced cross-sections, e+Au/e+p
- Without EIC pseudo-data, large uncertainties, especially for sea quarks and gluons
- Adding in EIC pseudo-data significantly reduces the uncertainties for sea quarks and gluons, particularly at small-x

Effect of EIC psuedo-data on EPS09 fits



- Ratio of reduced cross-sections, e+Au/e+p
- Without EIC pseudo-data, large uncertainties, especially for sea quarks and gluons
- Adding in EIC pseudo-data significantly reduces the uncertainties for sea quarks and gluons, particularly at small-x
- Fitting the charm pseudo-data has a dramatic effect at high-x
    - ➡ Something the LHC, for example, will not be able to address

Effect of EIC psuedo-data on EPS09 fits



- Ratio of reduced cross-sections, e+Au/e+p
- Without EIC pseudo-data, large uncertainties, especially for sea quarks and gluons
- Adding in EIC pseudo-data significantly reduces the uncertainties for sea quarks and gluons, particularly at small-x
- Fitting the charm pseudo-data has a dramatic effect at high-x
  - ➡ Something the LHC, for example, will not be able to address